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Policy mixes for the sustainability transition of the pulp and paper industry in Sweden

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ABSTRACT

The need to view innovation policy through the lens of policy mixes has gained momentum given the growing complexity, the dynamics of real-world policy and the wide array of difficulties to address the current great societal challenges, notably the increasing pressure on the ecosystems that support our society. One of the main challenges concerning the transition towards bioeconomy, is to gain a more in-depth understanding on the policy mix to stimulate innovation in sustainability transitions.

Our paper aims at enriching the portfolio of empirical case studies on policy mixes for innovation and sustainable transitions, by investigating the development of the policy mix underpinning the sustainability transition of the pulp and paper industry in Sweden.

We apply a case study approach which draws on event history analysis, semi-structured interviews with industry and policy makers, literature reviews, a participative workshop with stakeholders from the pulp and paper industry, as well as on the IEA databases on climate change and energy efficiency policies and measures.

Our analysis emphasises coordination, timing and scale in policy mixes as important elements to understand how instruments interact to accelerate sustainability transitions. The mapping of the policy mix shows that destabilising policies were crucial for accelerating the transition process of the industry. Prior to novelty creation policies, destabilising policies (e.g. environmental policies) were needed for 'innovation policy instruments' to be effective.

More specific instruments (e.g. carbon tax), targeting particular functions of the innovation systems, require 'on-the-ground' policy intelligence and benefit from close interaction with industry.

1. Introduction

Addressing today's great societal challenges (e.g. climate change, food and energy security, poverty, deforestation) involves transition towards more sustainable economies which requires policy changes cutting across multiple sectors, policies “coherent across the boundaries, […], and that remain sufficiently flexible to prevent bottlenecks and expensive lock-ins” (Philp, 2017, p.2). Given that such a transition is a complex and long-term process, implying a variety of policy interventions to steer the direction and speed of innovative paths, an innovation system perspective is needed in which, “an important role for policymakers is to track technological fields of strategic importance, identify system strengths, stimulate positive feedback, and address system weaknesses that block further development by means of a combination of general and specific policy instruments” (Hellsmark and Söderholm, 2017, p.32).

Over the past decades, a systemic perspective on innovation (Freeman, 1987) has been highly influential not only to study conditions and processes of innovation at the level of regions, nations, industries and technological fields but also to inform policy-making and enable policy-analysis (Smits and Kuhlmann, 2004). In such analysis, most attention has been paid to policy priorities related to economic growth and competitiveness. More recently, a systemic perspective on innovation has also been applied in the field of sustainable transitions (Geels, 2002), referring to transformative shifts in systems of production and consumption that unfold as disruptive technological change (Kemp et al., 1998) which

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co-evolves with changes in markets, user practices, policy, discourses and governing institutions (Markard et al., 2012; Smith et al., 2010). In particular, analyses drawing on the technological innovation system approach have been explicitly focused on identifying systemic inducement and blocking mechanism in the emergence and growth of clean-technology based industries (Bergek et al., 2008; Hekkert et al., 2007). An important aspect and ambition of such analysis has been to identify failures in the innovation system requiring policy intervention for the 'build-up' of such industries and the acceleration of sustainability transitions (Coenen and Diaz Lopez, 2010).

An important consequence of a systemic perspective on innovation is the acknowledgement, that there is no single policy instrument that can act as a silver bullet to improve the functioning and performance of innovation systems in sustainability transitions. In light of this, it is not surprising that the notion of policy mixes has found considerable resonance with scholars in this field. As Edler. (2010, p. 2) note, "innovation policy is in fact a mix of policies and is itself a more or less integral part of a broader policy portfolio at various levels".

A recent contribution of Kivimaa and Kern (2016), has given a first suggestion how a policy mix framework can be applied to the field of sustainability transitions. Notably, following the Schumpeterian notion of creative destruction, their framework acknowledges the need to consider policies that not only respond to the creation of novelty but also to the destabilisation of existing unsustainable practices and structures, conceptualized as regimes. Their framework combines the analysis of key functions of technological innovation systems central for novelty creation in niches around emerging sustainable technologies with an analysis of central processes for the destabilisation of the incumbent regime addressed in transition theory (Kivimaa and Kern, 2016). An integration of both frameworks has been proposed earlier (Markard and Truffer, 2008), but in the analytical framework developed by Kivimaa & Kern the focus is on the role of policy instruments.

This paper seeks to complement this approach by focusing more explicitly on the coordination, timing and scale of the policy mix. As acknowledged by Kivimaa and Kern (2016) these dimensions have been neglected in previous frameworks and analyses. This is somewhat paradoxical given the importance that the notion of policy mixes ascribes to coordination and interplay of policies (see Fig. 1), and that the policy coordination failure has been recognised as a central problem in governing for innovations in sustainability transitions (Weber and Rohracher, 2012).

We therefore suggest including the importance of timing and scale when assessing the effectiveness of the policy mix. Policy strategies and instruments change over time, not only in terms of the contents and as a result of policy learning (Kivimaa, 2007), but also because their effects are interpreted against changing goals and rationales. Consequently, also the mix of instruments cannot be assumed to be stable over time. The extent to which the policy mix is internally consistent, complementary or conflicting may change considerable over different points in time.

To assess the effectiveness of a policy mix, it is thus key to consider the timing of different policy instruments to account for sequential logics that help explain why a certain instrument or set of instruments has made an impact (or not).

Likewise, it is important to consider how policy instruments are designed and implemented at different scales. Multi-level governance has been a well-established point of departure in innovation policy to account for the particularities of regional and national innovation systems (Fritsch and Stephan, 2005; Asheim and Coenen, 2005). This is also acknowledged in EU's recent smart specialisation strategy (McCann and Ortega-Argilés, 2013). More recently, the literature on sustainability transitions has also started

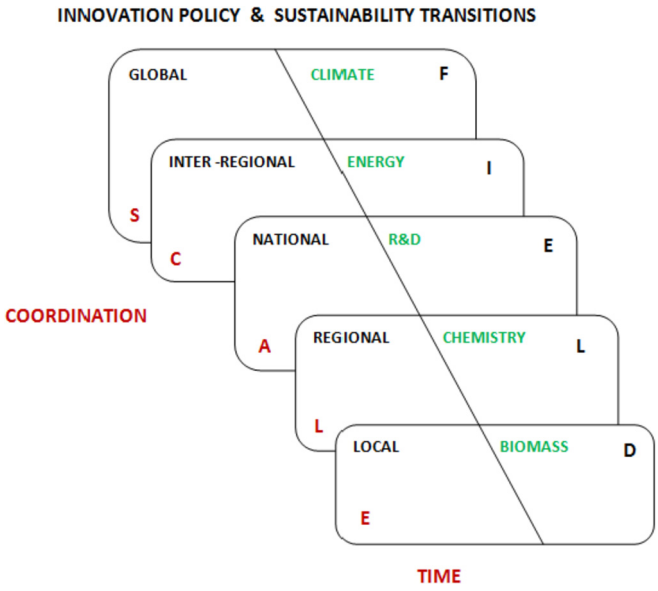

Fig. 1. Coordination, scale and timing of policy mixes for innovation policy and sustainability transitions (own elaboration).

to relax its previous fixation with the national level (see, e.g. Coenen et al., 2012; Hansen and Coenen, 2015) and started to account for the role of cities (Nevens et al., 2013), regions as well as supra-national levels of policy-making in governing transitions (Hodson and Marvin, 2011; Sengers and Raven, 2014). Innovation policies are no longer the responsibility of national governments alone; regional and supra-national organisations and bodies also implement these kind of policies (Borras and Edquist, 2013). Hence, we assume that paying attention to timing and scale of policies will provide useful insights on the extent to which different elements of a policy mix may be effective in accelerating a sustainability transition. Against this background, the aim of the paper is twofold:

(i) to identify which policy mix has been effective in inducing innovation that improves both environmental sustainability and economic competitiveness in the Swedish pulp and paper industry.
(ii) to assess to what extent these instruments have interacted to accelerate a sustainability transition in the industry and determine the importance of time and scale in this policy mix.

Our study seeks to enrich the portfolio of empirical case studies on policy mixes for sustainable transitions, by investigating the development of the policy mix underpinning the sustainability transition of the pulp and paper industry in Sweden.

We selected the Swedish pulp and paper industry (PPI) as a case study for mainly three reasons: first, it represents a sector which has reduced its negative environmental impact substantially during the last 40 years while at the same time maintaining a positive economic development; secondly, Sweden is an important actor on the global pulp and paper market and its dynamics may serve as interesting example for the sector worldwide; thirdly, the forestry sector is important for how it may contribute to a greening of the economy, as it is based on renewable materials that can be utilised in substitution of many fossil-based materials (Tillväxtanalys, 2014).

The remainder of the paper is, as follows: Section 2 presents core aspects of the theoretical framework. Section 3 introduces the research methodology, whereas Section 4, gives a short historical

narrative of the sustainability transition of the Swedish pulp and paper industry (Section 4.1), followed by the analysis of the role of the policy mix in this process (Section 4.2). Section 5 discusses the main findings, while Section 6 outlines the concluding remarks.

2. Theoretical framework

The Innovation System (IS) approach (Freeman, 1987) analyses conditions for promoting innovation and investigates which actors/organisations are involved in the innovation process, to what extent and how these are connected in networks, and which institutions enable or inhibit innovation processes. Besides providing a rich conceptual framework, the IS literature consists of a substantial body of mainly case-based empirical research, which has had a major influence on innovation policy (Edquist, 2005).

A system perspective on innovation goes beyond the neoclassical economic rationale that policy intervention is legitimate and needed due to market failure because of sub-optimal resource allocation by firms. Rather, it builds on the notion that innovation processes are social learning processes that take place in a context of networks and institutions. This implies that public intervention is legitimate and needed not only if the complex interactions that take place among the different organisations and institutions involved in innovation do not function effectively. Various authors (see, e.g. Klein Woolthuis et al., 2012; Smith, 2000) have identified structural system failures, which inform and shape system-oriented public policy support for innovation:

- Capabilities' failure: The lack of appropriate competencies and resources at the firm and organisational level may limit and/or prevent the generation of, access to, and exploitation of knowledge.
- Hard institutional failure: Absence, excess or shortcomings of formal institutions such as laws, regulations, and standards (in particular with regard to IPR and investment).
- Soft institutional failure: Lack of informal institutions such as social norms and values, culture, entrepreneurial spirit, trust and risk-taking that impede collaboration for innovation.
- Strong network failures: Intensive cooperation in closely tied networks leads to myopia and lack of infusion of new ideas.
- Weak network failures: Too limited interaction and knowledge exchange with other actors inhibits exploitation of complementary sources of knowledge and processes of interactive learning.

Following this line of argument, choice of policy instruments is determined in relation to the actual problems identified in the innovation system. This logic has been applied for example by Tödtling and Trippl (2005) in the context of regional innovation systems where typically large metropolitan regions suffer from a fragmented network structure.

Additionally, increasing policy complexity has made it common that many innovation policies "co-exist within the same country or region, based on different rationales, employing different instruments, and corresponding to different policy domains" (Magro and Wilson, 2013, p. 1647).

Various strands of literature - e.g. *innovation studies* (see among others, Flanagan et al., 2011; Cunningham et al., 2013; Nauwelaers et al., 2009), *policy analysis* (e.g. Howlett, 2005; Howlett and Rayner, 2007), and *environmental economics* (e.g. Braathen, 2007; Lehmann, 2012) have raised attention for and brought into discussion the concept of policy mixes.

Across the various strands of literature, the policy mix concept differs in terms of definition, scope or characteristics.[1] Different authors stress the need for

- "comprehensive, effective, economically efficient, robust, politically achievable, and inclusive climate policy mix" (Matthes, 2010, p.6),
- "coherence, coordination, and effectiveness of policy mixes" (Nauwelaers et al., 2009, p.11), and
- "consistent and effective policy mix which is congruent to long-term targets." (Schmidt et al., 2012, p.476).

Explicit discussion of the policy mix concept affecting innovation processes is fairly recent in the innovation policy discourse (Cunningham et al., 2013), and dates back to the mid-2000s, when the policy mix concept has gained importance in EU innovation policy, with a study commissioned by the EU with the aim to inform policy makers on which portfolios of policy instruments are most effective for achieving a higher quantity and performance of research investments (Nauwelaers et al., 2009). Increasing recognition among policy makers and international organisations (e.g. EU, OECD), has been mirrored also in an increasing academic interest for policy mixes focusing on stimulating, and enabling innovation in the context of sustainability transitions.

In the context of sustainability transitions it is argued that policy mixes need to address a strategic component, associated policy processes and the characteristics of policy mixes (Rogge and Reichardt, 2016). Moreover, these three "building blocks" may be analysed in terms of their elements: 1) Policy strategy (including policy objectives and principal plans) 2) Instruments (including their types and purpose) and 3) Policy processes (including policy learning and policy implementation aspects) (Rogge and Reichardt, 2016).

Empirical focus of policy mix studies in sustainability transitions has mostly been directed to the fields of renewable energy policies (see among others, Reichardt et al., 2016; Kern et al., 2017), biofuels (e.g. Falcone et al., 2017; Mardoyan and Braun, 2015), low carbon transitions (e.g. Kivimaa and Virkamäki, 2014), CO_2 emissions reduction in automotive sector (e.g. Van Der Vooren and Brouillat, 2015), adoption of electric vehicles (e.g. Bakker and Trip, 2013), biogas (e.g. Huttunen et al., 2014), and climate policy (Matthes, 2010).

2.1. Functions in technological innovation systems

More recently, scholars have however expressed concern with this static perspective system that primarily maps the actors, networks and institutions and only offers inventory-like descriptions of innovation systems (Uyarra, 2010). This critique is particularly salient in light of sustainability transitions where the ultimate objective is to structurally transform production and consumption systems which, consequently, implies a strategic transformation of an innovation system (Weber and Rohracher, 2012). This critique has been most readily addressed by the literature on technological innovation systems (TIS). To quote Hekkert et al. (2007):

> "In order to understand the determinants of change, insight in the present (static) structure of innovation systems is not sufficient. Ideally, we would like to grasp the dynamics of innovation systems in order to reach a better understanding of what really takes place inside these systems. Therefore, we propose to map the activities that take place within the system, since the process of change is the resultant of many interrelated activities" (p. 417–418).

[1] For an extensive literature review see among others Rogge and Reichardt (2016), Kivimaa et al. (2017).

To do so, TIS explicitly directs attention to the functional performance of the innovation system's components, conceptualised through a set of functions, as defined in two programmatic papers by Bergek et al. (2008) and Hekkert et al. (2007). This set of functions refers to: *(1) Entrepreneurial experimentation*: exploring and exploiting business opportunities on the basis of new technologies and applications. The applications create opportunities to experiment and learn about the functioning of new products, processes or services after exposure to market dynamics. *(2) Knowledge development and diffusion*: the creation of knowledge lies at the heart of any innovation process. While science-based research and development are important key processes to generate new knowledge, these are not the only ones. Various other types of knowledge can also serve as input for innovation, including experience-based knowledge development through doing, using and interacting (Jensen et al., 2007). For the development of new or improved products, processes or services, the diffusion of knowledge can be as important as the actual generation. Successful innovators are often those firms that know how to make commercial use of ideas and knowledge generated by others (Chesbrough, 2003). *(3) Guidance of the search* is necessary for the selection or rejection of a particular direction of technological development. The formulation of expectations and visions, priority setting in R&D strategies and foresight studies contribute to such selection processes. Also, user-producer interaction provides an important feedback mechanism in this context. *(4) Market formation*: innovation is by default couched in uncertainty as it often disrupts the status quo on existing markets. The more radical an innovation is the higher its disruptiveness. This means that incremental innovation, building forth on existing products, processes or services, is more likely to be accepted by existing users and markets while markets for completely new innovations often still need to be formed. *(5) Resource mobilisation* refers to the mobilisation and allocation of resources that are necessary to make the various processes in the innovation system, as described above, possible. Primarily they refer to the collective efforts to secure financial capital (seed and venture capital, policy support programmes) and human capital (through education, training and competence development). *(6) Creation of legitimacy* is required to overcome the liability of newness (Zimmerman and Zeitz, 2002), which constitutes an important but often neglected dimension of innovation. The purposeful creation of legitimacy by lobbying activities and advice activities on behalf of interest groups may be necessary in order to counteract resistance to change.

2.2. Regime destabilisation processes

By analysing weaknesses in the functional pattern of the TIS (i.e. “what is actually going on”), key blocking mechanisms are identified that, in turn, lead to a specification of the relevant policy issues (see, e.g. Jacobsson and Bergek, 2011; Wieczorek and Hekkert (2012). However, that functions alone cannot form the sole basis for policy, as these functions cannot be influenced by policy in any other way than by intervention in the structure. Moreover, Kivimaa and Kern (2016) have pointed out that, in a context of sustainability transitions, the analytical scheme of TIS is limited towards solely focusing on the creation of novelty whereas destabilisation or destruction of regime structures is left largely unnoticed. To fully account for the Schumpeterian processes of creative destruction, they therefore propose to complement the functional pattern of the TIS with a set of additional analytical categories that draw explicitly on the concepts of socio-technical regime (Geels, 2002, 2004) and regime destabilisation (Turnheim and Geels, 2012). Moreover, this approach stresses the importance of directionality, resistance and contestation in innovation processes, and thus, policy (Weber and Rohracher, 2012). Compared to TIS, it comprises a wider set of institutions and networks of heterogeneous actors including firms, user groups, scientific communities, policy makers, social movements and special interest groups.

For being able to address not just the structural failures of an existing innovation system, but also the needs for changes in the transformation of such systems Weber and Rohracher (2012) introduce the concept of transformational system failures, including directionality failure, demand articulation failure, policy coordination failure and reflexivity failure. For the theoretical framework of this paper the directionality failure and the policy coordination failure are central. Directionality failure stands for the inability to steer innovation towards a certain direction to meet identified societal challenges. Policies which try to address such failures have to develop shared future visions and to implement a portfolio of policies which are in line with these visions and which address the shortcomings of the old regime. Policy coordination failure points to a lacking coherence between policies at different scalars (vertical coordination failure), or across different sectors (horizontal coordination failure). The right timing and sequence of policy interventions falls also under policy coordination.

This set of regime destabilisation processes refers to *(1) Control policies* that put pressure on a regime and create an ‘extended level playing field’ for emergent and incumbent technologies to compete on fair and equal terms, e.g. by internalising the environmental costs of carbon emissions. *(2) Significant changes in regime rules* that allow for reconfiguration of the institutions that favour status quo and path dependence. *(3) Reduced support for dominant regime technologies*, e.g. through the removal of subsidies for fossil fuel technologies. *(4) Changes in social networks,* replacement of key actors. Deliberately breaking up established actor-network structures and developing different fora for interaction to bypass traditional policy networks could provide windows of opportunity for niche innovations (Kivimaa and Kern, 2016, p. 209). An overview of this analytical scheme, illustrated with empirical examples of potential policy instruments is provided in Table 1.

We agree with Kivimaa and Kern (2016) that this analytical scheme is indeed helpful to map and identify policy instruments that have the potential to drive sustainability transitions. It shows convincingly the need to consider how a mix of policy instruments impacts on sustainability transitions. It also demonstrates that similar policy instruments can have different (and potentially conflicting) effects on the functioning of an innovation system and the acceleration of a transition.

3. Data and methods

For operationalizing our theoretical approach, we use the case study of the Swedish pulp and paper industry (briefly illustrated in Sections 4 And 5), which draws on two literature reviews, an event history analysis, semi-structured interviews and a participative workshop with representatives of the Swedish pulp and paper industry, as well as on the IEA databases on climate change.

We developed the empirical foundation for the case study in four steps.

Firstly, we built the case study on two literature reviews concerning (i) existing academic and grey literature on the role of policy instruments on the development (in terms of environmental sustainability and competitiveness) of the pulp and paper industry in Sweden and in an international perspective (Scordato et al., 2013), and (ii) a review of the economics literature on the development of the Swedish PPI since the 1960's (Bergquist and Andersson, 2013).

Table 1
Policy instrument mix for sustainability transitions (adapted from Kivimaa and Kern, 2014).

Influence	Policy instruments
Creation of novelty (innovation)	
1. Entrepreneurial experimentation (C1)	Policies stimulating entrepreneurship and diversification of existing firms, advice systems for SMEs, incubators, low-interest company loans, venture capital.
2. Knowledge development and diffusion (C2)	R&D funding schemes, innovation platforms and other policies aiming to increase knowledge creation and diffusion through networking; subsidies for demonstrations; educational policies, training schemes, coordination of intellectual property rights, reference guidelines for best available technology.
3. Guidance of the search (C3)	Goals set and framing in strategies, targeted R&D funding schemes, regulations, tax incentives, foresight exercises, voluntary agreements.
4. Market formation (C4)	Regulation, tax exemptions, market-based policy instruments such as certificate trading, feed-in tariffs, public procurement, deployment subsidies, labelling.
5. Resource mobilisation (C5)	Financial: R&D funding, deployment subsidies, low-interest loans, venture capital. Human: educational policies, labour-market policies, secondment of expertise.
6. Creation of legitimacy (C6)	Innovation platforms, foresight exercises, public procurement and labelling to create legitimacy for new technologies, practices and visions.
Destructive (regime destabilisation)	
1 Control policies (D1)	Policies, such as taxes, import restrictions, and regulations. Control policies, for example, may include using carbon trading, pollution taxes or road pricing to put economic pressure on current regimes. Banning certain technologies is the strongest form of regulatory pressure (e.g. phase out of fluorescent light bulbs).
2 Significant changes in regime rules (D2)	Policies constituting, for example, structural reforms in legislation or significant new overarching laws. Historical examples of major rule changes include the privatisation and liberalisation of electricity markets in the 1990s which completely changed the selection environment within which utilities were operating.
3 Reduced support for dominant regime technologies (D3)	Withdrawing support for selected technologies (e.g. cutting R&D funding, removing subsidies for fossil fuel production or removing tax reductions for private motor transport).
4 Changes in social networks, replacement of key actors (D4)	Balancing involvement of incumbents for example in policy advisory councils with niche actors; formation of new organisations to take on tasks linking to system change.

Secondly, eleven semi-structured interviews[2] with the corporate energy and environmental coordinators in eight pulp and paper companies (see for details: Tillväxtanalys, 2014, p. 13) have been conducted. The interviews cover a broad range of actors in the industry, from traditional pulp and paper plants to producers of more advanced forest-based products in forest-based biorefineries.[3] To ensure triangulation of the data sources different additional actors were interviewed, such as policy makers and industry associations. *Annex B* provides an overview of the number and type of organisations involved. The main purpose of the interviews is to describe how policy instruments and other factors have influenced individual companies, thus creating a deeper understanding of how climate policy is perceived by industry stakeholders. Key focus was on the role of policy instruments that have historically shaped the PPI industry in Sweden in terms of economic competitiveness and environmental sustainability. All interviews were recorded and transcribed, and were reported on separately (Tillväxtanalys, 2014). Furthermore, the results of the case study were presented at a workshop where about 30 invited stakeholders were given the opportunity to comment on the results of the literature reviews and the interview-based analysis. The participants included beside the interviewees a broad range of participants from the industry and public authorities. The selection of the participants was made on the basis of the information provided in the interviews and the literature reviews. The workshop was not recorded.

Thirdly, after the literature studies and the interview analysis, we proceeded with the analysis of policies and policy measures to create a time-line and to write a narrative of the Swedish PPI. To this point we used the IEA databases on climate change and energy efficiency policies and measures[4] to check for policy instruments relevant for the development of the pulp and paper industry in Sweden and created an event time-line to reconstruct the main policy-relevant events important for the Swedish PPI. The knowledge from this analysis complemented the results from the first steps for writing our narrative of the industry and informed also the final step.

Finally, we applied the theoretical framework on policy mixes on the analysis of the policies and policy measures. In a mapping exercise, we distinguished between i) sector specific policies, ii) climate and energy policies with relevance for the specific industries, and iii) more generic innovation policies. The mapping provided the case study with data which we used in the analysis of the policy mixes. Drawing on all the empirical sources gathered in the first three steps, we applied the analytical scheme (Table 1) on the analysis of the policy mix which has been important for the Swedish PPI in terms of environmental sustainability. This means that the information from the literature reviews and the interviews informed our assessment of the policy measures. The analysis was made in following two steps:

(a) we categorized the different functions of the policy instruments in the transition process in line with the analytical scheme:
(b) we categorised the policy instruments identified in our case study by their influence (creation of novelty or regime destabilising).

4. Findings

4.1. Swedish pulp and paper industry case: an overview

The pulp and paper industry (PPI) is a relevant case to study as it represents an energy intensive industry, which has contributed

[2] Interviews were carried out face to face or by telephone, recorded and transcribed. The questions posed were essentially the following: What factors and policy instruments have been the most important for the sectors green transition during the last 3-4 decades? In what way have these factors affected the companies' competitiveness? What factors and policy instruments have been important for the creation of innovation and the entrance of new actors? The detailed interview guide is published (in Swedish) (Tillväxtanalys, 2014, pp. 53ff.).

[3] The interviews targeted companies such as pulp and paper plants, producers of tissues and hygienic paper products, and other niche producers (viscose and biodiesel).

[4] https://www.iea.org/policiesandmeasures/.

worldwide to high levels of pollution and CO_2 emissions. As a consequence, it is a sector which has been subject to different climate, energy and environmental policies and regulations. Moreover, the forest industry is central to the current EU policy debates about the role of woody biomass in generating renewable energy, and in supporting the bio-based economy and the circular economy (Giurca and Spath, 2017; Sikkema et al., 2017). Tensions about the expansion of wood energy in the European Union have spurred discussions about the need for coherence between policy fields and instruments which relates not only to the forest sector but also to related industries, energy, agriculture, food industries and waste management (see, e.g. Maina et al., 2017; Marousek et al., 2015).

Globally, Sweden is a strong actor on the pulp and paper market and is the world's second largest exporter of paper, pulp and sawn timber. It is estimated that Sweden's bioeconomy constitutes 7.1 percent of Sweden's total value added and 22.9 percent of the total goods exported in 2014. And about two thirds of this value added came from the forestry sector (Tillväxtanalys, 2016). The entire forestry sector (including pulp and paper) is of key importance for the Swedish economy, with a yearly turnover of approximately 130 billion SEK (12 per cent of national GDP) and providing employment for about 76.000 people of which 22.000 are employed in the pulp and paper industry (Ottosson, 2011). In addition, about 100.000 people are indirectly involved in the sector through services, maintenance and other related activities. Few large actors dominate the sector, of which the four largest companies Holmen, SCA, Södra and Stora Enso together represent 64 per cent of the production of pulp and 60 per cent of paper in Sweden (Ottosson, 2011).

While the pulp and paper sector had a high productivity growth in the 1990s, production volumes have been shrinking since 2000 and are today at historically low levels (Bergquist and Andersson, 2013). Rising market competition from Asia and South America has posed challenges to the strategic reorientation of many pulp and paper industries in Sweden and in other Western countries. Because the international demand for newspaper paper has diminished due to this global competition and the digitalisation of the media market the production of newspaper paper has halved over the last 10 years. However, the Swedish PPI is less specialised in newspaper paper and has specialised more in packaging etc. Therefore, the total production of the Swedish PPI reduced just by 12% over the last ten years (Tillväxtanalys, 2016). A challenge remains to invest in newer and more efficient mills (especially for pulp production) and to explore new pathways to be able to compete globally. For Swedish firms, and for PPIs in other countries, the biorefinery concept may offer promising new business opportunities for sustainable value creation if adopted and open involvements in new value chains. Turning towards biorefining is argued as a promising solution for pulp and paper companies currently struggling with value creation (Karltorp and Sandén, 2012; Patari et al., 2011) and could play an important role in the transition to a bio-based economy and in generating more jobs (Formas, Vinnova and the Swedish Energy Agency, 2012). However, the pulp and paper industry has been assessed as very conservative and more focused on protecting existing business structures (Bauer et al., 2017).

As a sector, the PPI is highly capital and energy intensive and major investments are hence required to develop new technologies. Increasing and fluctuating energy prices play a central role in strategic decision making in the sector and energy prices have as a consequence a significant effect on industrial change in the sector (Davidsdottir and Ruth, 2005).

Historically, the competitiveness of the Swedish pulp and paper sector has been based on low energy prices, skilled work force, high quality forest resources, efficient transportation infrastructure and efficient product and process development (Rametsteiner et al., 2009). In the last two decades, increased competition from other countries, regulations and increasing electricity prices have created incentives to invest in energy efficiency, to produce biofuels and other renewable electricity. Compared to other industrial sectors, the Swedish pulp and paper industry represents an example of an industrial sector which has gone from being a serious polluter to a largely sustainable industry. The transition started in the early 1970s and a substantial reduction in pollutants and carbon dioxide emissions have occurred in parallel with an increase in the shares of output growth (Bergquist and Soderholm, 2016). The industry's plants of the pulp and paper sector are today climate neutral except for its industry-related transportation. Moreover, the sector is currently one of the major renewable energy producers in the country (Ericsson et al., 2011). In an international perspective, the Swedish pulp and paper industry has the lowest carbon emissions per tonne of product in the world followed by Norway, Finland and Canada (IEA, 2007). As we will describe more in detail in this paper, the environmental legislation and Sweden's energy and climate policy have been crucial to this development.

4.2. Development of the policy mix influencing the transition of the pulp and paper industry in Sweden

Our analysis of the policy mix for the pulp and paper sector in Sweden shows that there has been a range of instruments that have had a clear influence on the sectors' sustainability transition. While the national policy strategies and rationales underpinning the instruments have changed over time, they had a significant effect on the transition of the pulp and paper industry in Sweden.

In the 1960's the Swedish PPI was responsible for large environmental problems. The heavy emissions of large quantities of soot and sulphur dioxide was cause of concern and consequently environmental legislation and a new system with individual licences was introduced at the end of the 1960s (Naturvårdsverket, 1997). The regulatory policy with individual licences initiated a process of gradual environmental adaptation of the industry and spurred the PPI to invest in environmental technology.

The introduction of environmental legislation and requirements for individual licences in 1969 represent an essential control policy in the transition process. The new legislation was moreover a decisive factor for the industries to start investing in environmental technologies. The analysis indicates, however, that for the pulp and paper industry the introduction of improved energy efficiency technologies only played a minor role in the transition. Success factors are instead explained by the specific attributes of the environmental legislation, which set out to define clearly defined and binding goals, flexible implementation and competent, solution oriented dialogue between industry and the regulatory authorities (Tillväxtanalys, 2014).

In the following decades, **demand** for more environmentally friendly paper products such as chlorine free paper, by consumers and environment organisations accelerated the PPI's attention on shifting towards more sustainable production methods (Soderholm et al., 2017). In the same period, the sector started to focus on implementing energy efficiency technologies and replacing fossil fuels with biofuels.

The largest share of reduction of carbon dioxide emissions in the Swedish pulp and paper industry took place over the period 1973–1990. In this period, the pulp and paper sector reduced its carbon emissions from 8 million to 1.8 million tons (Bergquist and Andersson, 2013). The national energy policy for oil independence and the change in the overall energy mix at the national level had a significant impact on the industry's climate adaptation. In Sweden,

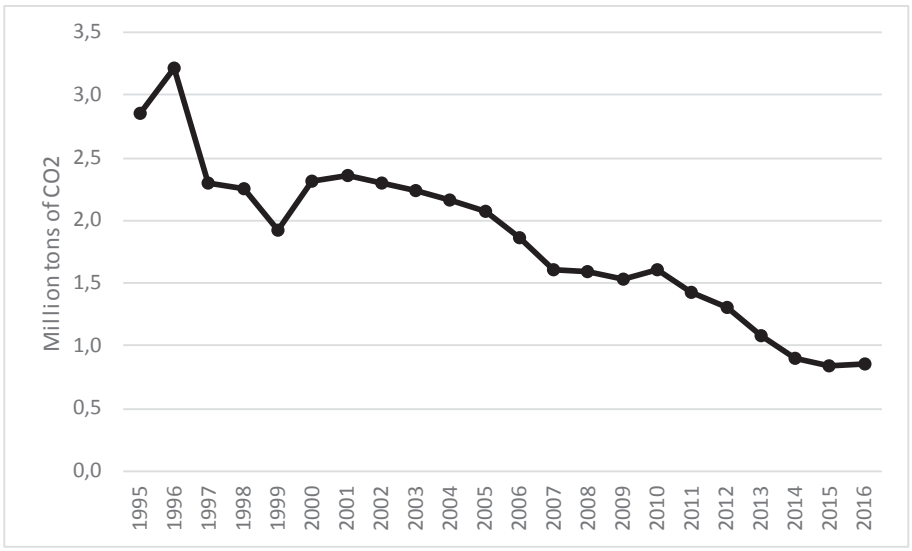

Fig. 2. Carbon dioxide emissions from manufacture of paper and paper products in Sweden, in million tons (Source: Eurostat). Note: Values until 2008 based on NACE Rev. 1.1, values after 2008 based on NACE Rev. 2.

the oil crises in the 1970s and 1980 contributed to policies aiming at reducing oil dependency and a search for alternative fuels at the government level and within industry (Lindmark et al., 2011). The development and expansion of nuclear power and hydropower gave the Swedish PPI access to abundant fossil free energy at a low electricity price. As also been argued by Lindmark et al. (2011), a significant part of the reduction of emissions from the Swedish PPI took place before the introduction of active climate policy instruments in the two past decades, such as the carbon dioxide tax and the sulphur tax Lindmark et al. (2011).

Nonetheless, the policy-led transition which drove the Swedish energy system away from fossil fuels to more environmentally friendly energy, such as biofuels after the mid-1990s contributed further to carbon emission reductions in the PPI sector. In the same period, the energy intensity however increased in parallel to increasing production volumes and value added (Tillväxtanalys, 2014).

In spite of that, policy instruments introduced after the 1990s had only some part in the transition (see Fig. 2). The PPI has nevertheless continued to invest in energy efficiency measures and in green electricity production, mainly as a cost-reduction strategy due to volatile and increasing electricity prices.

The deregulation of the Swedish electricity market in 1996 affected substantially the PPI's investment strategies. The reform implied a steady increase in electricity prices and opposite to industry's expectations, the deregulation led to higher electricity prices and weakened Sweden's competitive advantage with respect to traditionally low energy prices compared with other countries in Western Europe (Ericsson et al., 2011). Consequently, cost-cutting strategies by improving electricity efficiency became important to reduce exposure to increasing and volatile electricity prices. Hence, the deregulation of the Swedish electricity market, introduced in 1996, induced significant **changes in regime rules** and had important effects on energy efficiency investments and on other investment patterns. After the 1990s, the policy mix was characterised by generic instruments (mainly taxes and charges) with a clear climate policy focus. The carbon dioxide and sulphur tax and the NO_x charge, had to some extent an impact on the transition of the pulp and paper industry but did not have a significant impact.

In terms of **guiding the search** and of **creating a market** the Programme for Energy Efficiency in energy intensive industries (PFE) and the Electricity Certificate System (ECS) appear to have had a certain impact. First, the Industrial Energy Efficiency Programme (PFE) led to increased investments in energy efficiency measures in the PPI (Thollander and Ottosson, 2008).[5] Process innovations at the mills were fostered by the introduction of the Swedish Standard for Energy Management Systems (EMS), which was an important part of the PFE. Industries participating in the programme commit to work continuously on energy related improvements, such as energy efficiency increase, use of renewable energy carriers and increase renewable energy production and/or sales (Ottosson and Magnusson, 2013). Second, the Electricity Certificate System (ECS) was a driver for the industry (especially chemical pulp mills) to invest in new wind turbines, which was essential in order to enable the production of biomass-generated electricity (Ottosson and Magnusson, 2013) and was an important driver behind the sector' s investment plans for wind power (Ericsson et al., 2011).[6] The ECS and the PFE were both designed to meet the requirements of the EU Renewable Energy Directive and the European Union's Energy Tax Directive. In addition to country specific measures the pulp and paper industry is affected by instruments initiated at the EU level such as the European Emission Trading Scheme (EU ETS). When introduced in 2005 the EU-ETS was the first international policy instrument to target PPI's carbon emissions (Gulbrandsen and Stenqvist, 2013). Previous studies (Mo and Zhu, 2014) have shown that the ETS has not been a successful instrument in terms of implementation of cost-effective energy efficiency investments and on inducing companies to

[5] The PFE scheme is a voluntary measure introduced in 2005 and designed to give energy intensive firms a guaranteed tax exemption if they join the programme and follow the mandatory requirements including continuous investments in energy related improvements, energy efficiency increase, use of renewable energy carriers and renewable energy production and/or sale (Ottosson and Magnusson, 2013). All Swedish pulp and paper companies participate in the programme.

[6] The policy aim of the ECS was initially to increase electricity production from renewable energy sources (RES) by 10 TWh by 2010 compared to 2002. In 2009, the growth target was increased to 25 TWh by 2020. According to the scheme producers of electricity receive tradable renewable energy certificates (so called TRECs). Electricity producers receive one electricity certificate for each MWh of renewable electricity they produce. Electricity intensive industries are excluded from the quota system, which makes the pulp and paper industry exempt from buying TRECs.

adopt active climate strategies. The generous or even excessive amount of trading permits of the scheme have been attributed to the limited impact that it has had on reducing energy intensity of the Swedish industry (Gulbrandsen and Stenqvist, 2013; Thollander and Ottosson, 2008). This has been confirmed also in more recent studies (Lundgren et al., 2015; Stenqvist and Ahman, 2016). Especially relatively low carbon prices did not put sufficient pressure on the Swedish PPI to find innovative solutions (Lundgren et al., 2015). In this context, it is important to consider the **scale of the policy mix**. National policies appear to have been significantly more effective than the supranational ones and this higher impact is still prevailing. There is support for this claim in both the literature review and from the interviews. There are also differences between policies, like the PFE and ECS, which were implemented to meet EU directives but designed in accordance to national circumstances. Knowledge about the specific characteristics of the national industry is hence important in order to achieve the desired policy effects. On the other hand, EU-ETS had limited or no effect on the transition, in terms of incentivising the PPI to develop low carbon innovations. In sum, national and specific policy instruments have been significantly more effective than both the generic and national and supranational policies. This brings us to consider the importance of the role of multilevel-governance in transitions and on the importance of coordination and coherence of policies at different governance levels.

In sum, our analysis suggests that a combination of increased policy attention on oil independence and climate change issues, reduced support for dominant regime technologies combined with instruments influencing the direction of search[7] were of fundamental importance for the transition. Fig. 3 summarises our **findings**, and presents an overview of the development of the policy mix and other factors, which have contributed to the sustainability transition of the Swedish pulp and paper industry during the past four decades. A table of policy instruments is presented in *Annex A*.

By analysing the development of the policy mix affecting the pulp and paper industry we see that environmental regulation combined with long-term strategic reorientation of government energy policy played a central role in the transition process. In addition, changes in regime rules regulating electricity prices significantly affected industries' energy efficiency strategies and production of renewable energy. The instruments included in our analysis have had to a less extent an effect on innovation in the sector, with perhaps a few exemptions such as the PFE, which, according to the industries themselves, contributed to innovative energy efficiency processes. The analysis identifies the most important exogenous factors, which contributed to accelerate the transition, namely price of oil and national policy for oil independence, rising electricity prices, environmental concern of consumers and society.

5. Discussion

In this paper, we have built upon a case study on the Swedish pulp and paper industry (PPI) aiming at: (i) identifying which policy mix has been effective in inducing innovation that improves both environmental sustainability and economic competitiveness; and ii) assessing to what extent these instruments have interacted to accelerate a sustainability transition of the industry, paying particular attention on the importance of coordination, time and scale in this policy mix.

Building on the empirical evidence gathered through our four-step methodological approach, the following observations can be pointed out.

First, the case study on the Swedish PPI shows that no single policy instrument is capable of achieving a transition, but a policy mix framework is needed to understand the role of policy instruments in guiding a sustainability transition of energy intensive industries - i.e. pulp and paper industry, that holds uneven power relations, and in which the settings tend to favour those traditional players who have the power and the means. As a matter of fact, the pulp and paper industry has been assessed as very conservative and more focused on protecting existing business structures (Bauer et al., 2017).

Furthermore, our first observation and the need for a policy mix framework which pays particular attention at dimensions like coordination, time and scale, are in line with the remark reported by Beland Lindahl et al. (2017a):

"(t)here is an 'implementation deficit', that is to say, instruments and other measures have been decided on and put in place, but are not being applied on a sufficient scale. Where policy instruments fail to have the intended effect, it is often due to conflicts between competing interests, not uncommonly environmental versus economic" (Swedish Environmental Protection Agency, 2014; cited in Beland Lindahl et al., 2017a, p. 52).

Secondly, we found that the instruments in the IEA databases were foremost characterised by the functions of novelty creation. However, the mapping of the policy mix shows that destabilising policies were crucial for accelerating the transition process of the industry.

Destabilising policies seem to be needed prior to novelty creation policies in order for 'innovation policy instruments' to be effective. Otherwise, resistance to change and vested interests may prevail. This remark is in consonance with the concern raised, in a previous study, about the fact that "the prevailing mechanisms for implementation and participation result in a relatively closed system for making decisions, […]" a weak mechanism to implement innovation policies, "[…] is likely to result in "more" for those who have voice and influence, and "less" for those who lack resources and networks" (Beland Lindahl et al., 2017a, p. 54).

Thirdly, such destabilisation policies often target the industry as a whole. While initially introduced at the national level, policies have increasingly aimed to meet requirements of EU wide objectives due primarily to concerns related to carbon leakage and loss of competitiveness. In this regard, our case study indicates that more specific instruments, targeting particular functions of the innovation systems (e.g. PFE and carbon tax), require 'on-the-ground' policy intelligence and benefit from close coordination and interaction with industry. Such a close interaction of industry and policy is also needed for designing new policy support for biorefineries (Palgan and McCormick, 2016). When introduced at the European level these may suffer from implementation difficulties (as illustrated by EU-ETS). This observation refers to the importance of considering the scale of policy instruments and on the level of effectiveness of policy instruments stemming from different levels of governance.

Another relevant issue to take into account is that the notion of policy mix does not only refer to the set of instruments that target problems of an innovation system or sustainability transition, it encompasses broad policy domains. These domains range from science, technology and innovation policies to related fields such as climate, energy and environmental policy. It is hence important to consider the role of sector policies in analysing sustainability transitions.

[7] The Energy Research Programme was launched in 1975; the Biofuels programme in 1992; the Long-term Energy Programme 1998–2004. From 2007 to 2010, the Swedish Energy Agency (SEA) financed a biofuel R&D programme and from 2007 to 2011 an ethanol programme with a budget of 144 million SEK. The biofuel R&D programme, running from 2011 to 2015 focuses on feedstock provision (refining waste from forestry and agriculture), processing and sustainability of biofuel.

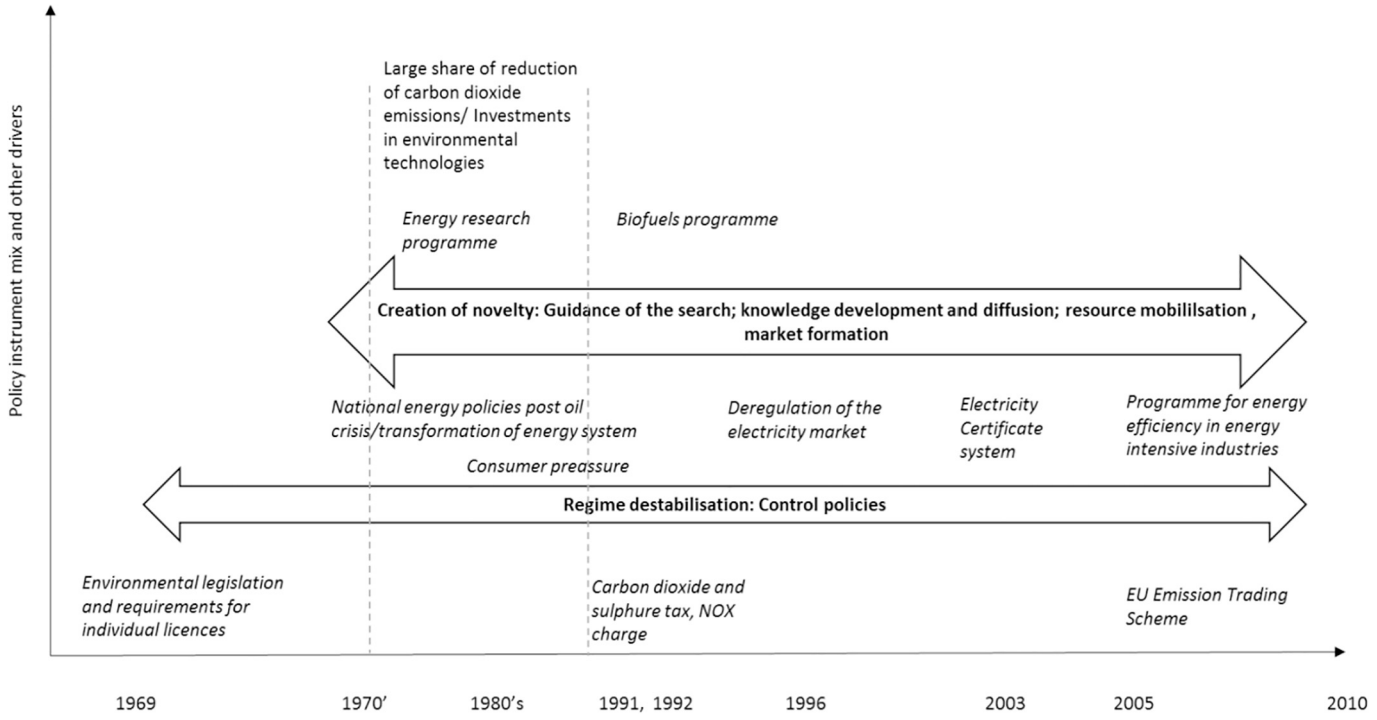

Fig. 3. Development of the policy mix influencing the transition of the Swedish PPI (own illustration).

In the case of Sweden, this goes hand in hand with its "More of Everything" pathway (Beland Lindahl et al., 2016), and the willingness "to seek ways to integrate policy across sectors, promote deliberation and introduce new management approaches" (Beland Lindahl et al. 2017b, p. 74). However, "whereas a governance system may be strong in opening up to meet new sustainability challenges, it may at the same time lack capacity to make trade-offs and implement objectives" (Beland Lindahl et al. 2017b, p. 76). This is why it is important that dimensions like coordination, time and scale should not be overlooked or underestimated when designing or implementing policy mix frameworks for sustainability transitions.

6. Conclusions

The analytical framework and the four-step methodological approach enabled us to capture a comprehensive "policy mix picture" of the Swedish pulp and paper industry.

Our research findings indicate that sustainability transition of the pulp and paper industry in Sweden is driven by a policy mix in which destabilising policies (e.g. environmental regulations, requirements for individual licences, etc) were crucial for accelerating the transition process, by creating incentives for the actors acting in the sector to reorient in order to maintain their competitiveness and to meet sustainability challenges.

Nevertheless, we are aware that our study presents also a series of limitations. For instance, we did not cover with our analysis the issues of over-allocation, initial free allocation of permits, low prices and how these issues might relate to innovation and the sustainability transition in the paper and pulp industry in Sweden. This is an opportunity for further research which may led us to a broader range of findings and interpretations.

Additionally, although we aimed at assessing to what extent the policy instruments have interacted to accelerate the sustainability transition of the pulp and paper industry, we did not touch upon how these instruments were negotiated or by which trade-off mechanisms were enacted within the institutional framework.

These aspects could be investigated in a further research study along with other factors that affect the dynamics of windows of opportunity; windows of opportunity which can be exploited by pro-active players in the industry and which can steer the innovation policies.

Finally, the concept of "motors of creative destruction" is necessary in the analysis of sustainability transitions. Innovation policy debates need to include policy mixes with destabilising effect in addition to technology push and demand-pull instruments. The functions of innovation approach is useful but needs further refinement. The way it is currently framed, makes it rather difficult to distinguish between the different functions – there is a lot of overlap (both creation of novelty and destruction of regime). The framework would benefit from more clear definitions. Hence, making further refinements to the conceptual framework would allow for improved comparability with future empirical cases.

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Annex A

Table 2
Policy mix influencing the transition of the Swedish pulp and paper industry

Policy instrument	Influence	Role in transition
Environmental legislation and requirement for individual licences (1969)	Control policies (D1); had also an influence in terms of: Knowledge development (C2); Guidance of search (C3); Market formation (C4).	The regulatory policy initiated an extensive transition in the forest industry. Success criteria: clearly defined binding goals, flexible implementation and competent, solution-oriented dialogue between industry and the regulatory authorities.
National energy policies (in the '70 and '80)	Guidance of the search (C3); Knowledge development and diffusion (C2); Resource mobilisation (C5).	The oil crises and the redirection of the Swedish energy system away from fossil fuels in the 70′ and 80′ represent important historical dynamics that accelerated the transition.
Energy Research programme (1975)	Knowledge development and diffusion (C2); Resource mobilisation (C5).	Provided R&D knowledge base and R&D resources for introduction of new technology.
Carbon dioxide and sulphur tax (1991)	Control policies (D1). Had also and effect in terms of Guidance of the search (C3).	The CO_2 tax has played some part in the transition.
Biofuel programme (1992)	Knowledge development and diffusion (C2); Resource mobilisation (C5).	Provided R&D knowledge base and R&D resources for introduction of new technology.
NO_x charge (1992)	Control policies (D1)	The NO_X charge has contributed to lowering nitric oxide emissions from energy producers
Deregulation of the electricity market (1996)	Guidance of the search (C3); Significant changes in regime rules (D2).	Rising electricity prices had an important effect on energy efficiency investments and on other investment patterns.
Electricity Certificate System-ECS (2003)	Market formation (C4); Knowledge development and diffusion (C2); Entrepreneurial experimentation (C1).	The ECS had an important effect in terms of investments in electricity production based on biomass. But limited effect in terms of innovation. It was a driving force for investments in new turbines in chemical pulp mills and in wind energy.
Programme for Energy Efficiency in energy intensive industries-PFE (2005)	Guidance of the search (C3); Knowledge development and diffusion (C2); Control policies (D1).	The PFE has led to increased investments in energy efficiency measures. Process innovations at the mills were fostered by the introduction of the Swedish Standard for Energy Management Systems (EMS), which is an important part of the PFE.
EU-Emission Trading Scheme – EU-ETS (2005)	Control policies (D1)	Limited effect on the transition (concerning a greening of the industry and developing low carbon solutions).

Annex B. Interviewed companies and organisations

- Paper mills:
  - o SCA Ortvikens Pappersbruk;
  - o Arctic Papper Grycksbo AB
- Pulp mills:
  - o Södra Cell AB
  - o StoraEnso
- Tissue and Hygiene:
  - o SCA EDET Bruk
  - o METSÄ Tissue
- Niche products:
  - o Domsjö Fabriker AB
  - o Sunpine
- Swedish Forest Industries Federation
- The Swedish Forest Agency
- Ministry of Industry and Energy

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